Arctic Sea Ice Thickness Observations

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1. GOAL

To continue and expand the critical network of observations aimed at monitoring and understanding changes in the thickness and mass balance of the Arctic sea ice cover to a) improve the fundamental understanding of the role of the sea ice cover in the global climate system and b) explore the sensitivity of the sea ice cover as an indicator and potential amplifier of climate change.

2. OBJECTIVE

To achieve these goals the primary activities of this ongoing program are to: (a) establish and maintain a large-scale sea ice mass balance observing system, (b) provide near real time access to the data, (c) integrate the ice observations with atmosphere and ocean measurements, and (d) analyze the data to improve the understanding of changes in the mass balance of the Arctic sea ice cover.

3. APPROACH

Understanding the ongoing changes in the Arctic sea ice cover requires a system approach, integrating ocean, ice, and atmosphere studies. We look to continue our efforts to observe and attribute changes in the mass balance of the sea ice cover. This project is designed to be an integral part of the Arctic Observing Network (AON), acting in coordination with other ongoing efforts that have extensive oceanographic and atmospheric components. These collaborating programs currently include the North Pole Environmental Observatory (NPEO), Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMCOLES), the Beaufort Gyre Observing System (BGOS), and the Seasonal Ice Zone Network (SIZONET). The overarching goal of this work is to enhance these and other similar programs by exploring what ice thickness changes are occurring and how these changes occur.

The sea ice thickness observing system consists of an array of drifting ice mass balance buoys (IMBs) and a sea floor mounted ice profiling sonar (IPS). The IMB is an autonomous, ice-based system (Richter-Menge et al., 2006). Data from the IMB provide a time series of snow accumulation and ablation, ice growth, ice surface and bottom melt, internal ice temperature fields, and temporally-averaged estimates of ocean heat flux. Taken together these data delineate whether there has been a change in the mass balance of the ice due to ice growth, surface melt, bottom ablation, or snow accumulation. The important capability of the IMB to gain insight on the driving forces behind the change cannot be duplicated by any other in situ or remote autonomous measurement system currently available. The IMB buoys are also equipped to measure position, sea level pressure (SLP), and surface air temperature (SAT). Data on SLP and SAT are designed to be compatible with similar data collected from the more basic drifting buoys deployed under the International Arctic Buoy Program (IABP). The IMBs are deployed in coordination with other programs. This approach helps reduce the logistics costs and, more importantly, facilitates the co-location of complementary instrument packages designed to measure oceanic and atmospheric conditions.

The IPS provides a direct measurement of the ice draft and, assuming isostatic equilibrium, an indirect estimate of total ice thickness (Melling et al, 2005; Melling and Riedel, 1996). Following the guidance from a state-of-the-art sea ice dynamics model (Lindsay and Zhang, 2006), the moored IPS site was established in August 2003 on the Chukchi Plateau at 75°06.0' N, 168° 00.0' W. This site has been designated CH01. Instruments presently on the mooring have sufficient battery and data storage capacity to operate for two years. In 2006, the single release (2-year rating) was replaced with a tandem release assembly with 3-4 year endurance. Support for the servicing of the CH01 mooring site and analysis of the data are provided by RUSALCA.

Data collected from the IMBs and IPS are made widely available via the web site:
http://imb.crrel.usace.army.mil/.

4. PROGRESS

NOAA began its support of the ice thickness observing system in 2003. Since then and in collaboration with other programs, a total of 38 IMBs have been deployed in the Arctic Ocean. The IMBs provide a means to observe changes in the sea ice mass balance. These observations can then be integrated with other data to understand the changes in sea ice. For instance Perovich et al. (2008) combined the IMB data with model results and satellite observations to explain a dramatic increase in bottom melting in the Beaufort sector in 2007, which was more than six times the annual average value for the 1990s (Figure 1). Perovich et al. determined that an increase in open water fraction triggered a 500% positive anomaly in solar heat to the upper ocean providing the primary source of heat for the observed bottom ablation. This case exemplifies the ability of IMB results to attribute observed changes and to enhance our understanding of those changes.

The IMB data are being used by the remote sensing community for the development and evaluation of algorithms and to interpret satellite observations. IMB ice temperature data have been used to evaluate and improve QuikSCAT retrievals of the onset of melt in spring and freezeup in fall (Nghiem et al., 2007). IMB snow depth and ice thickness observations have been used to demonstrate that ICESat freeboard retrievals are within 10 cm of IMB surface-based measurements (Kwok et al., 2007). IMB results can continue to give baseline data to support the development of sensors and algorithms to remotely sense snow depth, ice thickness, and the onset of melt and freezeup. The IMB results can also be used to understand remotely observed changes in ice thickness. For example, semiannual airborne and satellite surveys of ice thickness can measure seasonal and interannual changes in ice thickness. Surface based IMB observations can attribute those changes to ice growth, surface melt, or bottom melt (e.g. Haas, 2008; Giles et al., 2008).

As currently designed, the IMB is limited to deployment in thick, multiyear ice. We have begun work on a new version of the IMB that can be deployed in thinner seasonal ice. A fundamental change is to go from a unit that uses a main housing and instruments attached via umbilical to a single hull design. This version would be easier to install, requiring only 1 drill hole and would have no exposed wires. Additionally, the new version IMB would be neutrally buoyant, facilitating its deployment in thinner ice conditions.

The CH01 mooring site has been recovered and redeployed four times, in 2004, 2005, 2007 and 2008. Ice conditions prevented it's recovery in 2006, however a second mooring was deployed in 2006 to avoid a lapse in the data set. Data from the first two cycles has been analyzed in preparation for posting on the web site.

The web site has been developed to provide a near real time reporting capability for IMBs that are actively transmitting data. These data are posted with a cautionary note indicating that they are provisional. Once an IMB stops transmitting, the data are thoroughly reviewed, archived, and posted on the web site. Data will also be submitted to the Cooperative Arctic Data and Information Service (CADIS) archive, consistent with the protocol of the Arctic Observing Network.

5. REFERENCES

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6. FIGURES

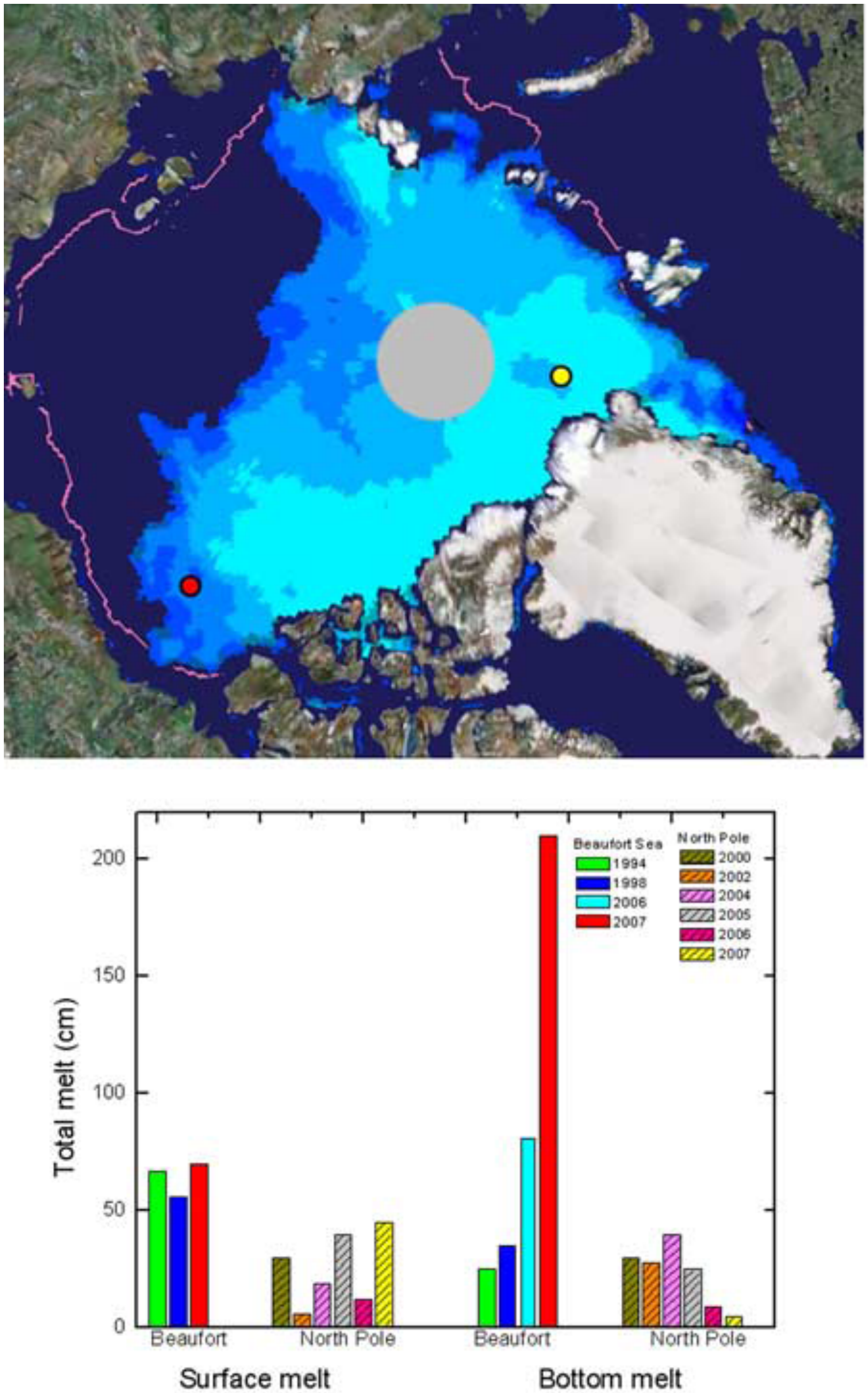

Figure 1. (top) The ice extent on 27 August 2007 courtesy of the National Snow and Ice Data Center and Google maps. The shades of blue show the percent area covered by ice from 0% (dark) to 80–100% (light). The red dot is the position of the Beaufort Sea buoy, and the yellow dot is the position of the North Pole buoy. (bottom) Observations of total surface and bottom melting in different years in the Beaufort Sea and North Pole regions (from Perovich et al, 2008).